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(54) **LOCALIZATION WITH SYNCHRONIZED EMISSIONS FOR COUPLED WHEELS**

(71) Applicant: **Continental Automotive Systems, Inc.**, Auburn Hills, MI (US)

(72) Inventors: **Alexander Fink**, Oakland Township, MI (US); **Jean-Christophe Deniau**, Fenton, MI (US)

(73) Assignee: **Continental Automotive Systems, Inc.**, Auburn Hills, MI (US)

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B60C 23/00 (2006.01)
B60C 23/04 (2006.01)

(52) **U.S. Cl.**
CPC ***B60C 23/007*** (2013.01); ***B60C 23/0416*** (2013.01); ***B60C 23/0489*** (2013.01)

(58) **Field of Classification Search**
CPC B60C 23/007; B60C 23/0416; B60C 23/0489
USPC 701/29.4
See application file for complete search history.

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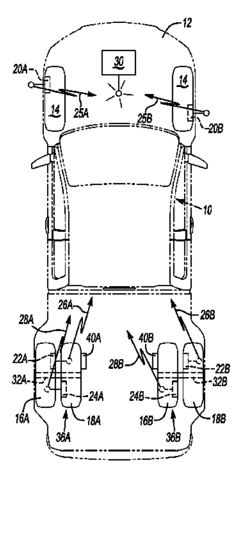
Primary Examiner — John R Olszewski
Assistant Examiner — Todd Melton

(57) **ABSTRACT**

A disclosed system for monitoring and locating a position of a tire pressure monitoring device within a tire includes a controller configured to detect a first transmission from a first sensor installed within a first wheel and a second transmission from a second sensor installed within a second wheel coupled to the first wheel. The controller and system utilizes a relative angular position corresponding to receipt of the transmissions to identify a lead and trailing tire pressure monitoring device. The controller is then enabled to correlate the signals with a known sequence of sensors to determine within which of the coupled tire assembly includes which tire pressure monitoring device.

20 Claims, 4 Drawing Sheets



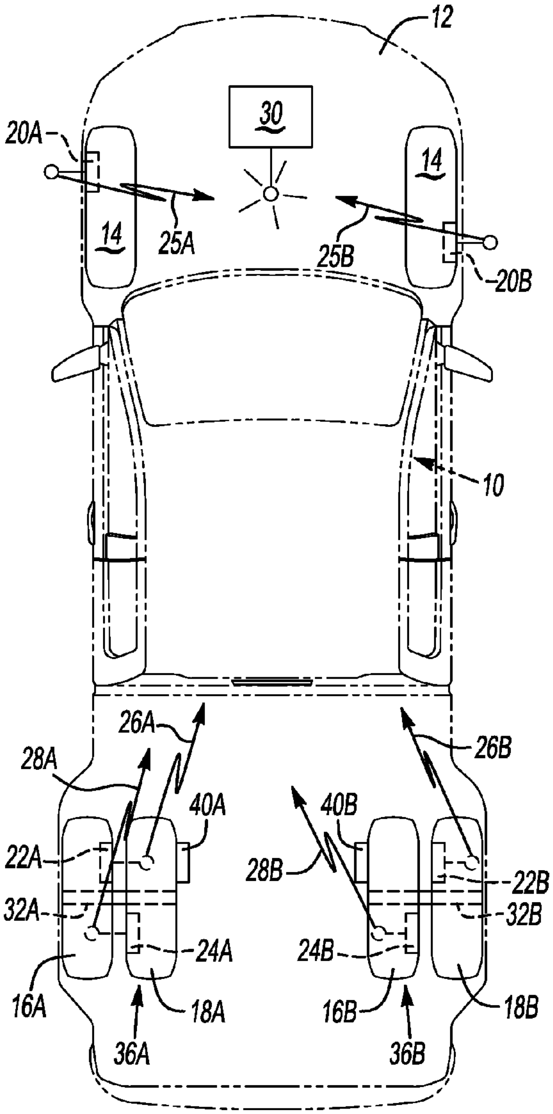

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Fig-1

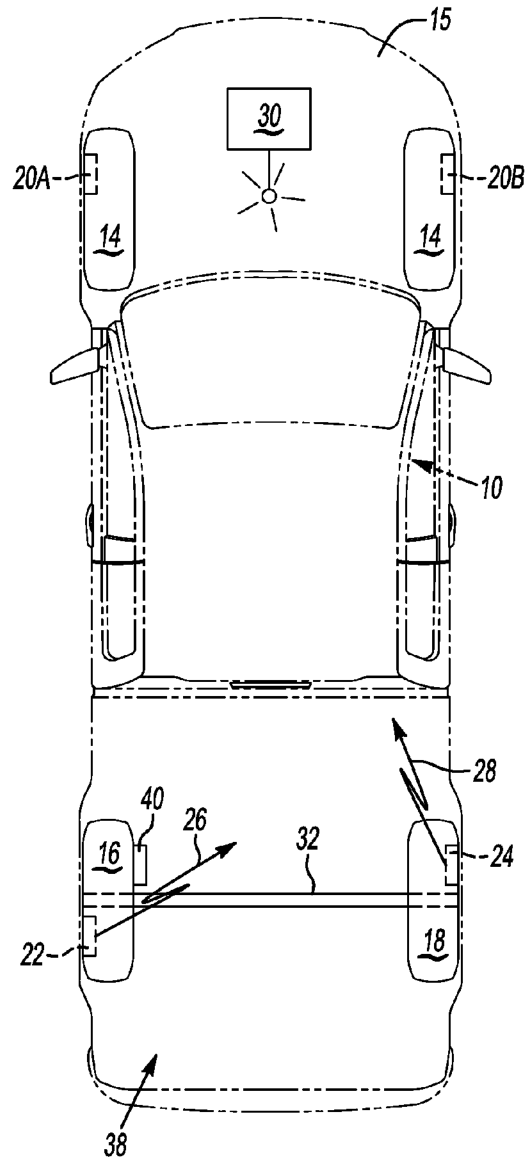
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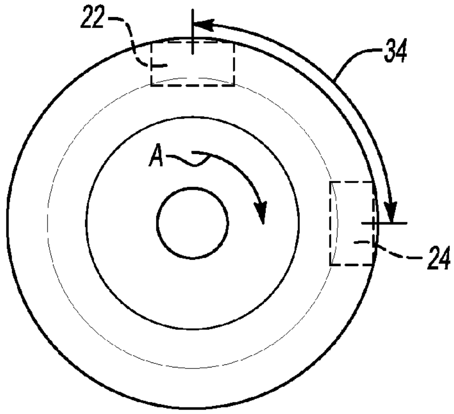
Fig-2



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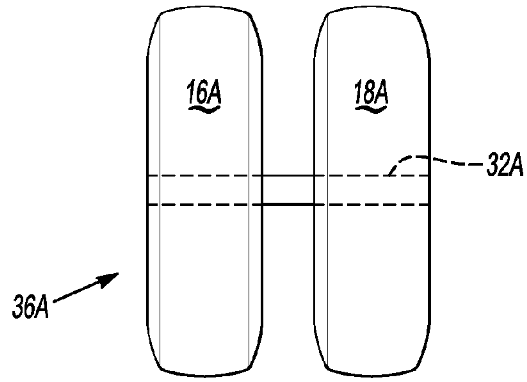
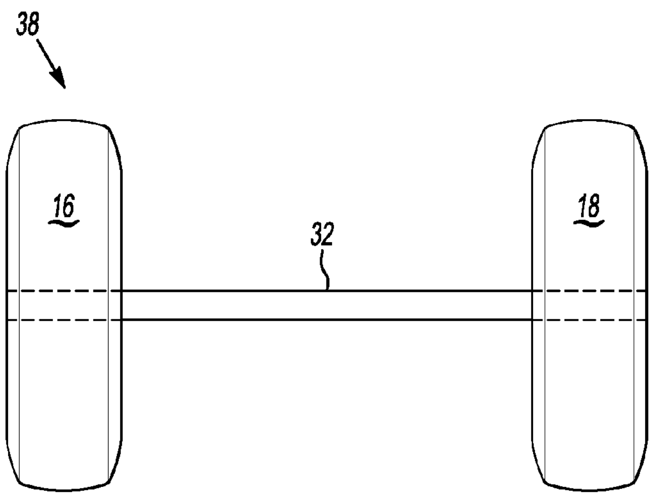


Fig-4A



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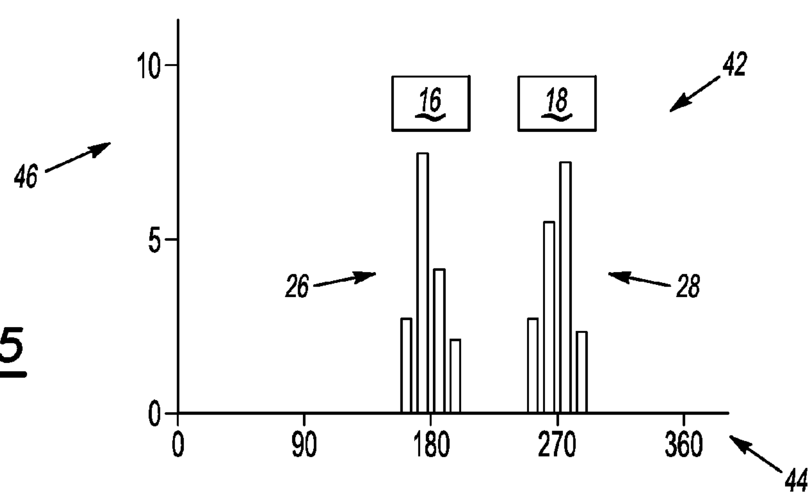

Fig-5

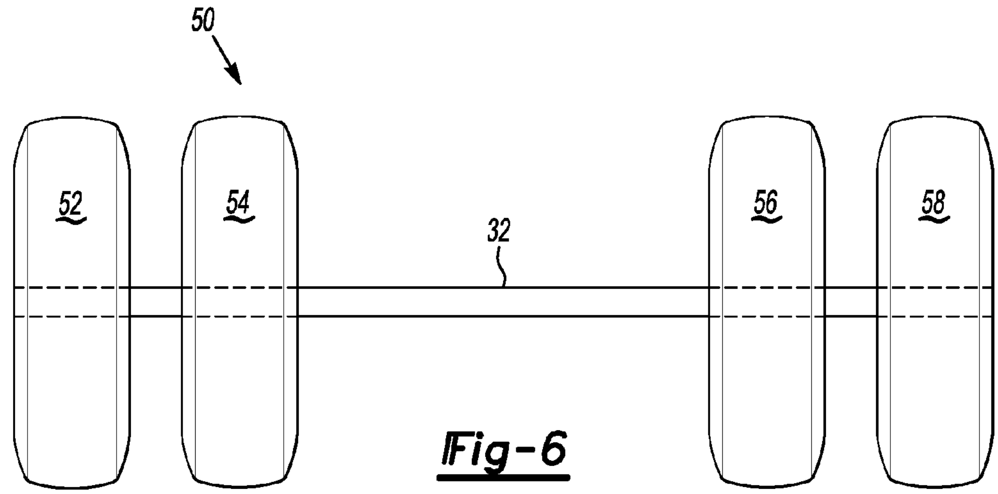

Fig-6

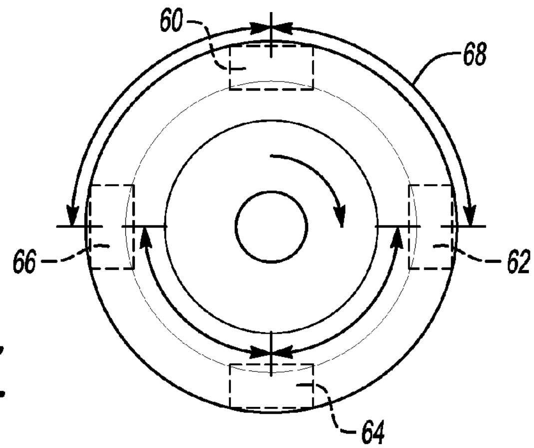

Fig-7

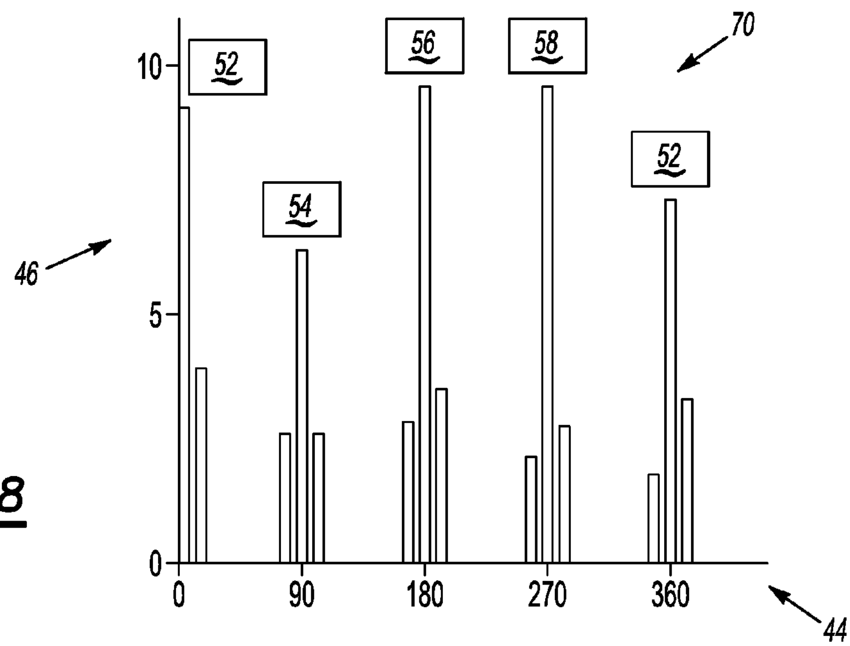

Fig-8

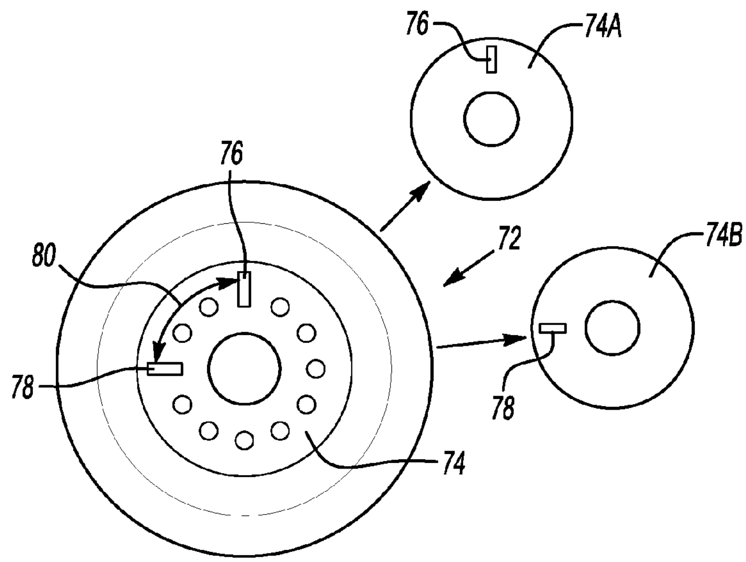

Fig-9

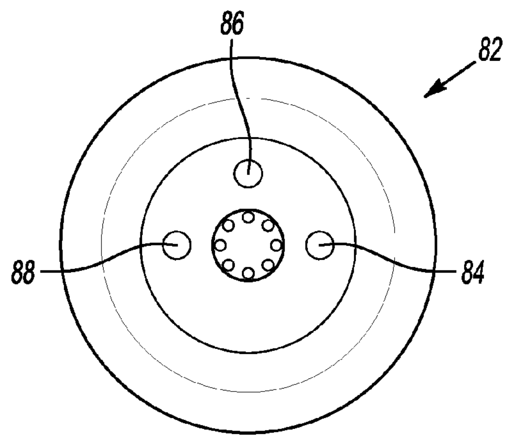

Fig-10

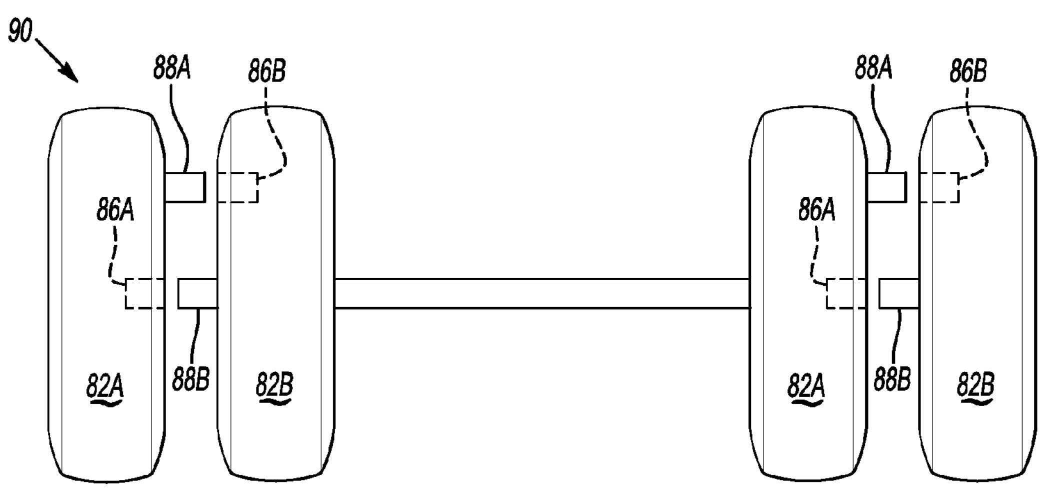

Fig-11

LOCALIZATION WITH SYNCHRONIZED EMISSIONS FOR COUPLED WHEELS

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority to U.S. Provisional Application No. 61/731,306 which was filed on Nov. 29, 2012.

BACKGROUND

This disclosure generally relates to a system and method of determining a location of a tire pressure monitoring sensor. More particularly, this disclosure relates to a system and method for determining a location of a tire pressure monitoring sensor within a coupled wheel configuration.

Tire pressure monitoring devices are mounted within vehicle wheels to sense and communicate information indicative of tire conditions to a controller such that a driver may be alerted when conditions deviate from desired conditions. Current systems associate an identification code of the sensor with a specific tire location. This association of each sensor with a tire location can be accomplished automatically using known unique rotation patterns and paths for each individual tire and correlating those unique patterns with incoming signals. Such location techniques rely on different wheel rotations for each of the wheels. However, such techniques cannot differentiate between sensors mounted within coupled wheels that rotate at common speeds.

SUMMARY

An example disclosed system and method provides for the localization of tire pressure monitoring devices within coupled wheel assemblies.

The system includes a controller configured to detect a first transmission from a first sensor installed within a first wheel and a second transmission from a second sensor installed within a second wheel coupled to the first wheel. The controller is further configured and programmed to correlate a first angular position with one of the first and second transmissions and a second angular position with the other of the first and second transmissions. The relative angular positions between the tire pressure monitoring sensors is known and enable the controller to determine the location of each of the first and second sensors based on a comparison between the angular positions of the transmissions.

Although the different examples have specific components shown in the illustrations, embodiments of this invention are not limited to those particular combinations. It is possible to use some of the components or features from one of the examples in combination with features or components from another one of the examples.

These and other features disclosed herein can be best understood from the following specification and drawings, the following of which is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic view of a vehicle including an example tire pressure monitoring system.

FIG. **2** is a schematic view of another vehicle including the example tire pressure monitoring system.

FIG. **3** is a schematic illustration of the relative position between first and second tire pressure monitoring devices disposed on separate wheels of a coupled wheel.

FIG. **4*a*** is a schematic view of a coupled wheel assembly.

FIG. **4*b*** is another example of a coupled wheel assembly.

FIG. **5** is a graph illustrating a number of received signals relative to an angular position.

FIG. **6** is a schematic view of another coupled wheel assembly.

FIG. **7** is a schematic view illustrating relative position between tire pressure monitoring sensors for the example couple wheel assembly.

FIG. **8** is a graph illustrating received transmissions relative to an angular position.

FIG. **9** is a schematic illustration showing alignment features.

FIG. **10** is a schematic illustration showing yet another embodiment of alignment features.

FIG. **11** is a schematic illustration illustrating the alignment features for the dual wheel assembly.

DETAILED DESCRIPTION

Referring to FIG. **1**, a disclosed tire pressure monitoring system **10** is schematically illustrated and mounted within a vehicle **12**. The vehicle **12** includes front tires **14** and rear coupled wheel assemblies **36*a***, **36*b***. The coupled wheel assemblies **36*a***, **36*b*** include a first wheel **16*a-b*** and a second wheel **18*a-b***. The corresponding first and second wheels **16*a-b***, **18*a-b*** are coupled by a physical link **32*a-b***. Each of the wheel assemblies **36*a***, **36*b*** includes a first tire pressure monitoring device **22*a-b*** and a second tire pressure monitoring device **24*a-b*** mounted in corresponding first and second wheels **16*a-b***, **18*a-b***. Each of the front wheels **14** includes a tire pressure monitoring device **20*a-b*** that sends a signal indicative of conditions within the tire. A controller **30** receives transmissions from the front tire pressure monitoring devices **20*a-b*** and the first and second tire pressure monitoring devices **22*a-b***, **24*a-b*** mounted within the rear coupled wheel assemblies **36*a***, **36*b***. The system **10** further receives information from a wheel speed sensor **40*a-b*** disposed at each of the coupled wheel assemblies **36*a***, **36*b***.

Referring to FIG. **2**, another example vehicle **15** includes a coupled wheel assembly **38** that includes first and second wheels **16**, **18** attached through a single rigid connection **32**. The rigid connection **32** extends across the vehicle **15**. The first wheel **16** includes the first tire pressure monitoring device **22** and the second wheel **18** includes the second tire pressure monitoring device **24**. The disclosed system **10** and method will be described with regard to the example shown in FIG. **1**, but is also applicable to the example illustrated in FIG. **2**.

Referring to FIG. **1**, the transmissions **25*a-b***, **26*a-b***, **28*a-b*** are radio frequency transmissions in a frequency modulated format known as FSK or an amplitude modulated format known as a ASK. As appreciated, other communication and signal formats are within the contemplation and scope of this disclosure. Transmissions **25*a-b*** are from the front tire pressure monitoring devices **20*a-b***, and the transmissions **26*a-b***, **28*a-b*** are from corresponding first and second tire pressure monitoring devices from the rear wheel assemblies **36*a***, **36*b***.

The controller **30** is configured to determine and associate each signal received with a specific one of the tire pressure monitoring devices **20*a-b***, **22*a-b***, and **24*a-b***. Each of the tire pressure monitoring devices **20*a-b***, **22*a-b*** and **24*a-b*** includes a unique identification code that is transmitted with each signal. A transmission can therefore be easily associated with a specific one of the tire pressure monitoring devices **20*a-b***, **22*a-b*** and **24*a-b***. However, the location of the tire pressure monitoring device and specifically the vehicle wheel associated with a particular one of the tire pressure monitoring devices **20***a*, **22***a-b* and **24***a-b* requires additional information.

Conventional location methods utilize different wheel speeds as communicated by wheel speed sensors **40***a-b* for each of the wheels to determine the location of the corresponding tire pressure monitoring sensor. Each individual tire pressure monitoring sensor rotates with one of the wheels and therefore each signal will correspond with a wheel position and speed unique to one of the wheels. Only one of the signals from the tire pressure monitoring device will correspond with an angular position and speed of one of the wheels as provided by the wheel speed sensor. However, in this example the rear wheel assemblies **36***a-b* are coupled and thereby the corresponding first and second wheels **16***a-b*, **18***a-b* rotate at a common speed and therefore the first and second transmissions **26***a-b*,**28***a-b* cannot be readily identified as they will not have unique combinations based on different wheel speeds.

Because the wheels **16***a* and **18***a* are coupled by a rigid mechanical link **32***a-b*, the wheels **16***a* and **18***a* will rotate identically and thereby not be distinguishable based on wheel speed. The wheel sensors **40***a-b* will detect a common rotation between the first tire **16***a-b* and the second tire **18***a-b* and thereby a common rotation of the tire pressure monitoring sensors **22***a-b* and **24***a-b*.

The example controller **30** is configured to recognize that the first transmission **26***a* and the second transmission **28***a* originate from the set of coupled wheels **36***a* that rotate at a common speed. The controller **30** is further configured to utilize a known relative mounting position between the tire pressure monitoring sensors **22***a* and **24***a* to determine which of the first and second wheels **16***a*, **18***a* corresponds with which of the first and second tire pressure monitoring sensors **22***a* and **24***a*.

In the example illustrated in FIG. **1**, the controller **30** will process transmissions from the first and second tires **16**, **18** of each of the coupled wheel assemblies **36***a*, **36***b* separately. Each of the wheel assemblies **36***a*, **36***b* will rotate at different speeds and therefore the controller **30** is configured to recognize and associate the wheel sensors **22***a-b*, **24***a-b* that are associated with each of the wheel assemblies **36***a*, **36***b*. The example method is described below with regard to a single one of the first and second coupled wheel assemblies **36***a*, **36***b* and is repeated for each coupled wheel assembly **36***a*, **36***b*.

Referring to FIGS. **3**, **4** and **5** with continuing reference to FIGS. **1** and **2**, the example method and system **10** utilizes a relative angular position between the tire pressure monitoring sensors **22**, **24** to determine and assign a location within each of the first and second tires **16**, **18**. The determined location refers to the first and second tires **16**, **18** of a coupled wheel assembly **36***a* in which the corresponding first and second tire pressure monitoring sensors **22***a*, **24***b* are mounted.

In this example, the first tire pressure monitoring sensor **22** within the first wheel **16** is mounted approximately 90° relative to the second tire pressure monitoring device **22** mounted in the second wheel **18**. The angular difference between the first tire pressure monitoring sensor **22** and the second tire pressure monitoring sensor **24** is indicated at **34** and is less than 180° to provide a clear difference between the first and second tire pressure monitoring sensors **22**, **24**. In this example the angle **34** is approximately 90° although any angle that is less than 180° could be utilized. As appreciated, if the sensors **22**, **24** were mounted 180° from each other there would be no determining which was leading or trailing.

Because both the sensors **22**, **24** converge on the same coupled wheel assembly **36***a* they can no longer be clearly distinguished by looking only at the speed of the wheels. The angular orientation, indicated in FIG. **3** of the first sensor **22** is utilized to determine a lead sensor and a trailing sensor. The lead sensor is that sensor from which a signal is first received for wheel rotating in the direction indicated by the arrow A.

FIG. **5** illustrates transmissions **26** and **28** and how they are received in relation to an angular position provided by the wheel sensor **40**. In this example, receipt of an identification tags and signals for sensors corresponding to the wheel sensor **40** is indicated by the graph **42**. Graph **42** illustrates the first transmission **26** and the second transmission **28** in relation to the angular position **44** of the coupled wheel assembly **36***a* at the time the signal is received. Signals from each of the sensors **22**, **24** are indicated as hits corresponding with the angular orientation **44**.

In this example, the angular orientation includes hits originating from a tire pressure monitoring device **22** within the first wheel **16** at 180°. A second group of transmissions **28** are gathered around a 270° angle and correspond with the second wheel **18**. The controller **30** is preprogrammed to recognize that a lead sensor when the wheel is rotating in the direction A is mounted within the first wheel **16** and the trailing sensor is mounted within the second wheel **18**.

Accordingly, it can be determined that the transmissions **26** from the lead sensor **22** are from the first tire pressure monitoring sensor **22***a* in the first wheel **16** and transmissions **28** from the second sensor **24** are in the second wheel **18**.

The localization task is therefore split into two steps. First the controller **30** recognizes that more than one signal is received at a time corresponding with one wheel speed sensor **40**. The controller **30** then determines which of the transmissions **26**, **28** are from a lead sensor and which is from a trailing sensor for rotation of the wheels in the forward direction indicated by arrow A. As appreciated, a vehicle traveling in reverse will have different lead and trailing sensor signals. In this example, the wheel direction is in the forward direction, however, the same method and techniques could be utilized with the vehicle traveling in reverse.

The controller **30** is then configured to proceed to a second step and correlate the receipt of the transmissions **26**, **28** relative to an angular position provided by the wheel speed sensor **40**. The controller **30** utilizes the known relative angular relationship between the tire pressure monitoring sensors **22***a* and **24***a* to determine which of the first and second tires corresponds with the first and second tire pressure monitoring sensors **22***a*, **24***a*. The identification made by the controller **30** relies on the known angular orientation between the first and second tire pressure monitoring devices **22**, **24**. Because the controller **30** recognizes that the tire pressure monitoring sensors are orientated apart by the angle **34** it is possible to determine and associate within which tire a sensor transmitting a signal is mounted.

Referring to FIGS. **6**, **7**, and **8** the example method can be utilized for the dual rigid axle combination including coupled wheels on both ends of a fixed axle indicated at **50**. The example dual fixed axle assembly **50** includes first, second, third and fourth wheels **52**, **54**, **56** and **58** all coupled to the fixed shaft **32** and therefore all rotate at a common wheel speed. In this example embodiment, each of the sensors mounted in the separate wheels at different spaced apart angularly by an angle **68**. In this example the angle **68** is approximately 90°. The controller **30** will first determine that each of a first, second, third and fourth tire pressure monitoring sensors **60**, **62**, **64**, and **66** are rotating at a common speed utilizing a wheel speed sensor disposed on the axle **32**.

Once the controller **30** has identified the tire pressure monitoring devices **60**, **62**, **64** and **66** that are rotating at a common speed, the controller **30** utilizes the known relative angular orientation between the devices **60,62,64** and **66** to determine within which tire the devices are located. In this example, each of the sensors **60**, **62**, **64** and **66** are all spaced apart by an angle **68** that is about 90°. The controller **30** is programmed to determine a lead sensor and then the sequence of devices that follow the lead sensor to determine and locate within which of the wheels **52**, **54**, **56** and **58** a sensor is mounted.

Referring to FIG. **9**, the example system and method relies on a known orientation of the tire pressure monitoring devices in a coupled wheel combination. Therefore the wheel rim can include features for setting a desired relative orientation of tire pressure monitoring sensors. In this example, a wheel rim **74** includes a first alignment feature **76** and a second alignment feature **78** that are spaced apart angularly at an angle **80**. In this example, the alignment feature **76**, **78** are slots into which a key portion of the tire pressure monitoring sensor is received to set the desired relative position. The alignment features **76**, **78** also aid in orienting the wheel rims **74** relative to each other such that upon assembly to the vehicle the coupled wheel combination positions the corresponding tire pressure monitoring sensors at the desired relative angular orientations.

Referring to FIGS. **10** and **11**, another example alignment feature is disclosed and includes a valve stem **84** that provides the position where the tire pressure monitoring device will be assembled. Each of the wheel rims **82** includes alignment features. In this example the alignment features include an opening **86** that receives a nipple **88**. Each of the wheels **82** includes both opening **86** and the nipple **88**. The orientation of the opening **86** and nipple **88** define and set the desired relative angular orientation between the coupled wheels, and thereby the relative position of the tire pressure monitoring devices.

Accordingly, assembling of the coupled wheel assemblies **90** provides that the nipple **88***b* is received within opening **86***a* and the nipple **88***a* on a first tire **82***a* is received within an opening **86***b* on a second tire **82***b*. The relative orientation between the tire pressure monitoring systems for each coupled wheel is therefore maintained and provided at the desired angular position. Although example alignment features are disclosed, other alignment configuration may be utilized to define and set a relative orientation between tire pressure monitoring sensors assembled within a coupled wheel assembly.

Accordingly, the disclosed method and system provides a significantly simple, cheaper and more reliable method and means for determining an origin of a signal generated by a tire pressure monitoring system within a coupled wheel assembly.

Although an example embodiment has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of this disclosure. For that reason, the following claims should be studied to determine the scope and content of this invention.

What is claimed is:

1. A method of configuring a controller to detect a location of a tire pressure monitoring sensor comprising:

configuring a controller to detect a first transmission from a first sensor installed within a first wheel;

configuring the controller to detect a second transmission from a second sensor installed within a second wheel coupled to the first wheel;

configuring the controller to recognize that the first wheel and the second wheel are comprised in a wheel assembly, the recognizing comprising detecting that the first wheel and the second wheel rotate at a common speed;

configuring the controller to correlate a first angular wheel assembly position with one of the first and second transmissions and a second angular wheel assembly position with the other of the first and second transmissions, wherein the correlating comprises correlating a tire pressure monitoring sensor identification tag with a respective one of first and second angular wheel positions at a time of receipt of a respective one of the first and second transmissions; and

configuring the controller to determine the location of each of the first and second sensors relative to the wheel assembly based on a comparison between the first angular wheel assembly position, the second angular wheel assembly position, and a predetermined relative angular relationship between the first sensor and the second sensor, wherein the determining of the location of each of the first and second sensors relative to the wheel assembly comprises determining which of the first and second sensors is a lead sensor and upon determining the lead sensor determining the location of at least one sensor other than the lead sensor relative to a vehicle and the wheel assembly based at least in part on the sequence of receipt of a transmission from at least one sensor other than the lead sensor with respect to receipt of a transmissions from the lead sensor, a relative angular position of the at least one sensor other than the lead sensor with respect to the lead sensor, and direction of rotation of the wheel assembly.

2. The method as recited in claim **1**, wherein the first angular wheel assembly position is separated from the second angular wheel assembly position by less than 180 degrees.

3. The method as recited in claim **1**, wherein the first angular wheel assembly position is separated from the second angular wheel assembly position by about 90 degrees.

4. The method as recited in claim **1**, including the step of configuring the controller to determine which of the first transmission and the second transmission correspond with a lead one of the first and second sensors and which of the first and second transmissions corresponds with a following one of the first and second sensors.

5. The method as recited in claim **4**, including the step of configuring the controller to recognize that the lead one of the first and second sensors corresponds with a predetermined one of the first and second wheels and that the following one of the first and second sensors corresponds with the other of the first and second wheels.

6. The method as recited in claim **1**, including the step of configuring the controller to recognize that the first transmission and the second transmission originate from first and second wheels rotating at a common speed.

7. The method as recited in claim **1**, wherein the predetermined relative angular relationship between the first sensor and the second sensor is set by assembling the wheel assembly.

8. A system for monitoring conditions within a tire comprising:

a controller configured to detect a first transmission from a first sensor installed within a first wheel, a second transmission from a second sensor installed within a second wheel coupled to the first wheel, the controller further configured to recognize that the first wheel and the second wheel are comprised in a wheel assembly, the recognizing comprising detecting that the first wheel and the second wheel rotate at a common speed, and to correlate a first angular wheel assembly position with one of the first and second transmissions and a second angular wheel assembly position with the other of the first and second transmissions, wherein the correlating comprises correlating a tire pressure monitoring sensor identification tag with a respective one of first and second angular wheel positions at a time of receipt of a respective one of the first and second transmissions, wherein the controller is configured to determine the location of each of the first and second sensors relative to the wheel assembly based on a comparison between the first angular wheel assembly position, the second angular wheel assembly position, and a predetermined relative angular relationship between the first sensor and the second sensor, wherein the determining of the location of each of the first and second sensors relative to the wheel assembly comprises determining which of the first and second sensors is a lead sensor and upon determining the lead sensor determining the location of at least one sensor other than the lead sensor relative to a vehicle and the wheel assembly based at least in part on the sequence of receipt of a transmission from at least one sensor other than the lead sensor with respect to receipt of a transmissions from the lead sensor, a relative angular position of the at least one sensor other than the lead sensor with respect to the lead sensor, and direction of rotation of the wheel assembly.

9. The system as recited in claim **8**, including first tire pressure monitoring device mounted within the first wheel and a second tire pressure monitoring device mounted within the second wheel.

10. The system as recited in claim **9**, wherein the first wheel and the second wheel include an alignment feature for orientating the first tire pressure monitoring device relative to the second tire pressure monitoring device.

11. The system as recited in claim **9**, wherein the first angular wheel assembly position is separated from the second angular wheel assembly position by less than 180 degrees.

12. The system as recited in claim **9**, wherein the controller is configured to determine which of the first transmission and the second transmission correspond with a lead one of the first and second sensors and which of the first and second transmissions corresponds with a following one of the first and second sensors.

13. The system as recited in claim **12**, wherein the controller is configured to recognize that the lead one of the first and second sensors corresponds with a predetermined one of the first and second wheels and that the following one of the first and second sensors corresponds with the other of the first and second wheels.

14. The system as recited in claim **9**, wherein the controller is configured to recognize that the first transmission and the second transmission originate from first and second wheels rotating at a common speed.

15. The system as recited in claim **8**, wherein the predetermined relative angular relationship between the first sensor and the second sensor is set by assembling the wheel assembly.

16. A system for monitoring conditions within a tire comprising:

a first tire pressure monitoring device mounted within a first wheel, wherein the first tire pressure monitoring device generates a first transmission indicative of conditions within the first wheel;

a second tire pressure monitoring device mounted within a second wheel coupled to the first wheel, wherein the second tire pressure monitoring device generates a second transmission indicative of conditions within the second wheel; and

a controller configured to detect a first transmission from a first sensor installed within a first wheel, a second transmission from a second sensor installed within a second wheel coupled to the first wheel, the controller further configured to recognize that the first wheel and the second wheel are comprised in a wheel assembly, the recognizing comprising detecting that the first wheel and the second wheel rotate at a common speed, and to correlate a first angular wheel assembly position with one of the first and second transmissions and a second angular wheel assembly position with the other of the first and second transmissions, wherein the correlating comprises correlating a tire pressure monitoring sensor identification tag with a respective one of first and second angular wheel positions at a time of receipt of a respective one of the first and second transmissions, wherein the controller is configured to determine the location of each of the first and second sensors relative to the wheel assembly based on a comparison between the first angular wheel assembly position, the second angular wheel assembly position, and a predetermined relative angular relationship between the first sensor and the second sensor, wherein the determining of the location of each of the first and second sensors relative to the wheel assembly comprises determining which of the first and second sensors is a lead sensor and upon determining the lead sensor determining the location of at least one sensor other than the lead sensor relative to a vehicle and the wheel assembly based at least in part on the sequence of receipt of a transmission from at least one sensor other than the lead sensor with respect to receipt of a transmissions from the lead sensor, a relative angular position of the at least one sensor other than the lead sensor with respect to the lead sensor, and direction of rotation of the wheel assembly.

17. The system as recited in claim **16**, wherein the first wheel and the second wheel each include alignment features for orientating the first tire pressure monitoring device in a different angular orientation relative to the second tire pressure monitoring device.

18. The system as recited in claim **17**, wherein the alignment features orientate the first tire pressure monitoring device at an angular orientation of less than 180 degrees from the second tire pressure monitoring device.

19. The system as recited in claim **16**, wherein the controller is configured to determine which of the first transmission and the second transmission correspond with a lead one of the first and second sensors and which of the first and second transmissions corresponds with a following one of the first and second sensors, wherein the controller is further configured to recognize that the lead one of the first and second sensors corresponds with a predetermined one of the first and second wheels and that the following one of the first and second sensors corresponds with the other of the first and second wheels.

20. The system as recited in claim **16**, wherein the predetermined relative angular relationship between the first sensor and the second sensor is set by assembling the wheel assembly.

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